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MIL-PRF-32516
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PERFORMANCE SPECIFICATION

ELECTRONIC TEST EQUIPMENT, INTERMITTENT FAULT DETECTION AND ISOLATION FOR CHASSIS AND BACKPLANE CONDUCTIVE PATHS

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the minimum performance requirements for equipment to detect and isolate nanosecond, microsecond and millisecond conductive paths (see 6.4.4) and intermittent faults (see 6.4.2), which can occur in any and all of the hundreds to thousands of Line Replaceable Unit (LRU)/Weapon Replaceable Assembly (WRA) chassis and backplane circuits and their wire harnesses. This specification is not intended to address hard opens (see 6.4.11), shorts (see 6.4.12), nor constant function failures found in routine electronics repair.

1.2 Classification. Diagnostic equipment is classified by its intermittent fault duration detection capability, as follows:

Category 1. Short duration intermittent faults (see 6.4.5) that are under 100 nanoseconds across all LRU/WRA backplane circuits and associated wire harnesses.

Category 2. Intermediate duration intermittent faults (see 6.4.6) that are 101 nanoseconds to 500 microseconds across all LRU/WRA backplane circuits and associated wire harnesses.

Category 3. Long duration intermittent faults (see 6.4.7) that are 501 microseconds to 5 milliseconds across all LRU/WRA backplane circuits and associated wire harnesses.

Comments, suggestions, or questions on this document should be addressed to the Naval Air Systems Command, (Commander, Naval Air Warfare Center Aircraft Division, Code 412000B120-3, Highway 547, Joint Base MDL, NJ 08733-5100) or emailed to michael.sikora@navy.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST online database at https://assist.dla.mil.

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2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of the documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATION

MIL-PRF-28800	-	Test Equipment for Use with Electrical And Electronic Equipment, General Specification for

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-130	-	Identification marking of U.S. Military Property
MIL-STD-810	-	Environmental Engineering Considerations and Laboratory Tests
MIL-STD-461	-	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-464	-	Electromagnetic Environmental Effects Requirements for Systems
MIL-STD-1472	-	Human Engineering

DEPARTMENT OF DEFENSE HANDBOOK

MIL-HDBK-235-1	-	Military Operational Electromagnetic Environment Profiles Part 1C General Guidance

(Copies of these documents are available online at http://quicksearch.dla.mil.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

CODE OF FEDERAL REGULATIONS

29 CFR 1910.1200	-	Occupational Safety and Health Standards
40 CFR 82	-	Protection of Stratospheric Waste
40 CFR 261	-	Identification and Listing of Hazardous Waste
40 CFR 355	-	Emergency Planning and Notification
40 CFR 372.65	-	Specific Toxic Chemical Listings

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49 CFR 173	-	General Requirements for Shipments and Packaging

(Copies of these documents are available online at http://www.gpo.gov/fdsys/browse/collectionCfr.action?collectionCode=CFR)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

EIA/ECA 310	-	Cabinets, Racks, Panels, and Associated Equipment

(Copies of these documents are available online at http://www.eciaonline.org.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified (see 6.3), a sample shall be subjected to first article inspection in accordance with 4.2. The number of samples will be defined by the procuring activity (see 6.2).

3.2 Diagnostic equipment capability. The diagnostic equipment shall detect and isolate (see 6.4.3) intermittent faults, one hundred (100) nanoseconds or greater in duration, that may be present in LRU/ WRA chassis/backplane circuitry and/or its wire harness. This testing would typically be conducted on LRUs/WRAs and/or their wire harnesses that have demonstrated low reliability and/or a repair history of No Fault Found (NFF) or quasi-NFF repair (e.g., cannot duplicate (CND), retest OK (RETOK), beyond capability of maintenance (BCM), disassemble-clean-reassemble (DCR), etc.).

3.3 Application. This diagnostic equipment shall interface with the input/output connections such as connectors and terminal boards of a replaceable package of avionic equipment or system (commonly referred to as LRU/WRA). The function of this diagnostic equipment is to troubleshoot the LRU/WRA chassis/backplane conductive paths. The LRU/WRA chassis conductive paths include all of the electrical components that transmit the signal or power from the LRU/WRA input/output connections to the input/output connections of replaceable packages (commonly referred to as SRA/SRU (shop replaceable assemblies/shop replaceable units)) in the LRU/WRA. For chassis/backplane diagnostic troubleshooting, the SRA is removed from the LRU/WRA. For SRA and/or entire LRU/WRA troubleshooting, the designated automatic test equipment (ATE) shall be used.

3.4 Detail requirements. The diagnostic equipment shall comply with all the requirements specified herein.

3.5 Material. The material used shall enable the diagnostic equipment to meet the performance requirements of this specification.

3.6 Operating environment. The diagnostic equipment shall operate in benign operational environments where the environmental conditions are controlled and protected.

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Examples include test equipment for use in a fully-protected and environmentally-controlled service area, such as a military depot level repair facility or industrial laboratory environment (see 6.4.10). The diagnostic equipment shall meet the environmental characteristics of this specification. Non-operating temperature shall be -20 degree Celsius (°C) to 71 °C; however, -40 °C is desirable. Operational temperature shall be 10 °C to 40 °C.

3.7 Design and construction. Diagnostic equipment shall be constructed with parts and materials designed to provide the specified performance, reliability, and service life under the environmental and operating conditions specified herein. Static discharge control shall be provided for protection of electronic devices during assembly and handling.

3.7.1 User interface. Diagnostic equipment shall be designed using an open-systems architecture approach, including the use of commercially available non-proprietary software. An open system is one that uses well-established, non-proprietary standards for interfaces, services, hardware, software, and supporting formats (e.g., Microsoft Excel, LabVIEW, USB (Universal Serial Bus), etc.). This enables components to be utilized across a wide range of systems, to interoperate with other components on local and remote systems, and to interact with users in a manner that facilitates portability.

3.7.2 Expandability. The diagnostic equipment shall facilitate test point expansion and growth (see 6.4.1). The diagnostic equipment shall include 256 test points per modular unit and be expandable to 1,280 tests points per 7U rack space (see EIA/ECA 310). The diagnostic equipment shall be expandable up to 10,000 test points without loss of fault detection performance capability. The final number of test points per modular unit and maximum test points shall be specified and approved by the procuring activity (see 6.2.u).

3.8 System physical characteristics (see 6.6).

3.8.1 Size and weight. The individual diagnostic equipment components shall not exceed the portability individual weight requirement of 35 pounds (16 kg) specified in MIL-STD-1472. The equipment shall be able to be safely moved without handles if less than 11 pounds (5 kg) or with handles if greater than 11 pounds (5 kg). The individual equipment shall be compatible with EIA/ECA 310 19-inch rack cabinets. The final size, weight, and EIA/ECA 310 compatibility of the diagnostic equipment shall be specified and approved by the cognizant procuring activity.

3.9 Performance characteristics. Diagnostic equipment shall perform electrical tests to determine the health and integrity of LRU/WRA chassis/backplane conductive paths or single wire/wire harness.

3.9.1 Fault detection. The diagnostic equipment shall detect all faults for the targeted classification category defined in 1.2 of this specification and identifying (see 6.4.3) the precise defective path(s).

3.9.2 Fault detection rate. The diagnostic equipment shall detect a minimum of 95 percent of all intermittent opens and shorts.

3.9.3 Integrity of point-to-point (pin-to-pin) wiring measurements. The diagnostic equipment shall verify test program parameters and output data (see 3.9.4) to indicate the number of occurrences and identify the conductive path(s) in which intermittent faults have occurred.

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3.9.4 Stimulus input. If voltage and current is applied during the intermittent diagnostic testing, the voltage and current provided shall not be injurious to the LRU/WRA.

3.9.5 Input power. The diagnostic equipment shall operate in accordance with the nominal and alternate power sources requirements and listed in Table I.

TABLE I. Power source.

<table>
<tr><th colspan="4">Voltage (Vrms)</th></tr>
<tr><td></td><td>Steady state</td><td>Transient state</td><td>Interruption</td></tr>
<tr><td>Nominal</td><td>108 to 132</td><td>84 to 108
132 to 156</td><td>0 to 84</td></tr>
<tr><th colspan="4">Frequency (Hz)</th></tr>
<tr><td></td><td>Steady state</td><td>Transient state</td><td>Interruption</td></tr>
<tr><td rowspan="2">Nominal</td><td>47.5 to 52.5</td><td>45 to 47.5
52.5 to 57</td><td>0 to 45</td></tr>
<tr><td>57 to 63</td><td>54 to 57
63 to 66</td><td>0 to 54</td></tr>
</table>

3.9.6 Diagnostic equipment startup and power-on self test. When energized or restarted, the diagnostic equipment shall run all power-on self-tests and be ready to operate in a typical work center in less than ten minutes. The diagnostic equipment shall provide automatic diagnostic information indicating whether it is operating within performance requirements. If the equipment is outside the limits of the performance specifications, the information provided by the self-test shall identify the likely cause of the fault.

3.9.6.1 Loop back test. The diagnostic equipment shall conduct a loop back test between the diagnostic equipment input/output connections. The purpose of the loop back test is to ensure the inter-connection harness between the diagnostic equipment and the LRU/WRA does not have any open/short circuits. The time to conduct the loop back test is separate and in addition to the startup and power-on self test.

3.9.7 Operating system. The operating system shall be an industry standard employing a “windowing” graphical user interface.

3.9.8 Data transfer. The diagnostic equipment shall have the ability to transfer test data (e.g., test results, wire signatures, and test programs) to an external device such as a memory stick, hard drive, optical drive, or other computer.

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3.10 Hazardous materials, ozone depleting substances and hazardous air pollutants.

3.10.1 Ozone depleting substances (ODSs). Title VI, Section 606 of the Clean Air Act calls for the elimination of the production of Class I ODSs by December 1995 and Class II ODSs by 2030 (with a 65 pecent reduction in production of Class II ODSs by 2010). No Class I ODS (as defined in Title VI of the Clean Air Act) or material containing a Class I ODS as an ingredient will be approved for use during any phase of the system's life cycle, which includes manufacture, operation, maintenance, and disposal.

3.10.2 Hazardous materials. The diagnostic equipment shall not require the use of hazardous or environmentally unacceptable materials throughout its life cycle, unless there is no feasible alternative. Hazardous materials are those meeting one or more of the following conditions:

a. Regulated as a hazardous material per 49 CFR 173

b. Requires a Material Safety Data Sheet (MSDS) per 29 CFR 1910.1200

c. Regulated as an Extremely Hazardous Substance (EHS) per 40 CFR 355, Appendices A and B

d. Regulated as a Toxic Chemical per 40 CFR 372.65

e. Meets or has the potential to meet the definition of hazardous waste, as defined by 40 CFR 261 Subparts A, B, C, or D, during end use, treatment, handling, packaging, storage, transportation or disposal

f. Regulated as an Ozone Depleting Substance (ODS) per 40 CFR 82 Subpart A, Appendices A and B

g. Identified in the Clean Air Act, Chapter 85, Subchapter I – 7412 as a Hazardous Air Pollutant (HAP)

3.11 Environmental characteristics. The diagnostic equipment shall meet the following operating/non-operational environmental requirements.

3.11.1 Temperature and humidity. The temperature ranges and humidity limits for both operating and not operating conditions shall be as specified in 3.13.1.1 to 3.13.1.3. A relative humidity of 95 percent (see 3.11.1.3) does not include conditions of precipitation.

3.11.1.1 Temperature, not operating. When tested in accordance with 4.5.6, the diagnostic equipment shall meet the performance characteristics of 3.9 after having been stored at non-operating temperatures of -20 to 71 °C.

3.11.1.2 Temperature, operating. When tested in accordance with 4.5.6 the diagnostic equipment shall meet the performance characteristics of 3.9 when operated at temperatures of 10 to 40 °C.

3.11.1.3 Humidity (see 4.5.6). The diagnostic equipment shall meet the performance characteristics of 3.9 where the relative humidity is 5 to 95±5 percent in the temperature range of 10 to 30 °C. The diagnostic equipment shall be subjected to conditions where the relative humidity is 5 to 75±5 percent in the temperature range of 30 to 40 °C, and where the relative humidity is 5 to 45±5 percent in the temperature range above 40 °C. At temperatures below 0 °C, the humidity is uncontrolled, but the equipment shall meet the performance characteristics

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of 3.9 (after the specified warm-up period) and shall withstand the effects of humidity up to 100 percent.

3.11.2 Altitude, not operating. The diagnostic equipment shall meet the performance characteristics of 3.9 after return from an altitude of 15,000 feet, when tested in accordance with 4.5.7.

3.11.3 Fungus resistance (see 4.5.8). The diagnostic equipment shall not contain materials that provide nutrients for the growth of fungus.

3.11.4 Random vibration. The diagnostic equipment shall meet the performance characteristics of 3.9 after random vibration conditions specified in Table II, when tested in accordance with 4.5.9.

Table II. Random vibration.

Duration per axis (minutes)	Frequency (Hz)	Slope (dB/Octave)	PSD (g^2/Hz)
10	5-100	0	.015
	100-137	-6	-
	137-350	0	.0075
	350-500	-6	-
	500	-	.0039

3.11.5 Bench handling. The diagnostic equipment shall meet the performance characteristics of 3.9 and there shall be no damage to controls, indicators, or fuse holders after being tested in accordance with 4.5.10.

3.11.6 Electromagnetic compatibility (EMC) (see 4.5.11). The diagnostic equipment shall perform in the following environments listed in Table V of MIL-STD-461: Ground, Navy. Additionally, the diagnostic equipment shall be designed to operate in the electromagnetic environments specified in MIL-STD-464 and MIL-HDBK-235-1 (for guidance only).

3.12 Marking and identification. Diagnostic equipment shall be marked with appropriate identification in accordance with MIL-STD-130.

3.13 Reliability. The diagnostic equipment shall have a mean time between failure in excess of 1500 hours.

3.14 Maintainability. The diagnostic equipment shall meet the maintainability requirements of MIL-PRF-28800.

3.15 Workmanship. The diagnostic equipment shall be free from irregularities or defects that could degrade performance or durability.

3.16 Safety. The diagnostic equipment shall meet the safety requirements of MIL-PRF-28800.

3.17 Government validation. The diagnostic equipment shall be tested in a laboratory environment by the government using an Intermittent Fault Emulator (see Appendix A and 4.5.12).

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4. VERIFICATION

4.1 Classification of inspections. The inspections specified herein are classified as specified as follows:

a. First article inspection (see 4.3).

b. Conformance inspection (see 4. 4).

4.2 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the test conditions specified in 4.5.

4.3 First article. First article inspections shall be performed on diagnostic units when required in accordance with Table III testing requirements. The number of first article units shall be as required in the contract or purchase order (see 6.2.d).

TABLE III. Summary of environmental requirements.

Environmental Conditions/Tests	Requirement	Test Methods
Temperature, not operating	3.11.1.1	4.5.6
Temperature, operating	3.11.1.2	4.5.6
Humidity	3.11.1.3	4.5.6
Altitude, not operating	3.11.2	4.5.7
Fungus resistance	3.11.3	4.5.8
Random vibration	3.11.4	4.5.9
Bench handling	3.11.5	4.5.10
Electromagnetic Compatibility (EMC)	3.11.6	4.5.11

4.4 Conformance inspection. The conformance inspections shall include the following inspection and tests:

4.4.1 Mechanical and visual examination. The equipment shall be given a thorough mechanical and visual examination, and test to determine that all materials, workmanship, and safety characteristics comply with the specified requirements.

4.4.2 Electrical circuit configuration. The equipment shall be examined or tested to confirm that the wiring is correct. Where applicable, the tests shall include the requirements specified in a and b:

a. All intra-module wiring shall be tested to assure correctness.

b. The module grounding system shall be examined or tested to ensure proper separation of shield, signal, and framework grounds, and metal-to-metal contact for panels and components that serve as electromagnetic shields.

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4.5 Test methods.

4.5.1 Test conditions. Unless otherwise specified in the detailed test herein, the inspection in 4.5 shall be performed under conditions a through d. Ambient conditions within the specified ranges need not be controlled. Measurements and observations shall only be taken after the diagnostic equipment has been turned-on and allowed to warm up for10 minutes (see 3.9.6).

a. Temperature: 25 °C ±10 °C
b. Humidity: 20 to 70 percent relative humidity.
c. Altitude: Sea level.
d. Power: See Table I.

4.5.2 Installation of test item in test facility. The diagnostic equipment shall be installed in the test facility in a manner that will simulate service usage, making connections and attaching instrumentation as necessary. Plugs, covers, and inspection plates not used in operation, but used in servicing, shall remain in place. When mechanical or electrical connections are not used, the connections normally protected in service shall be covered. For tests where temperature values are controlled, the test chamber shall be at standard ambient conditions when the test item is installed. The diagnostic equipment shall be operated to determine that no malfunction or damage was caused due to faulty installation or handling. The requirement for operation following installation of the test item in the test facility is applicable only when operation is required during exposure to the specified test.

4.5.3 Pretest. Prior to proceeding with the environmental tests, the test item shall be operated under standard ambient conditions (see 4.5.1) to evaluate the performance characteristics of the diagnostic equipment. This test is used to establish the level of performance of the diagnostic equipment at the outset of testing, prior to any environmental tests. This test is performed before, during, and after the environmental tests, whenever a satisfactory operational test is required. Degradation of the diagnostic equipment performance shall be noted if it exceeds any bound established in the purchase description.

4.5.4 Performance check during test. When operation of the diagnostic equipment is required during the test exposure, the pretest (see 4.5.3) shall be performed to determine whether the test exposure is producing changes in performance when compared with pretest qualification.

4.5.5 Post-test inspection. At the completion of each environmental test, the diagnostic equipment shall be inspected in accordance with pretest (see 4.5.3). The diagnostic equipment shall have failed the test when any of the conditions specified in a through g occur:

a. Monitored functional parameters deviate beyond acceptable limits established in 4.5.3.
b. Catastrophic or structural failure.
c. Mechanical binding or loose parts, including screws, clamps, bolts, and nuts, that results in component failure or a hazard to personnel safety.
d. Malfunction.
e. Degradation of performance beyond limits established in the purchase description.
f. Any additional deviations from acceptable criteria established before the test.
g. Deterioration, corrosion, or change in tolerance limits of any internal or external parts that could in any manner prevent the test item from conforming to operational service or maintenance requirements.

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4.5.6 Temperature and humidity. The temperature and humidity tests shall be performed in accordance with 4.5.6.1. Figures 1 and 2 show the temperature and humidity profiles. No rust or corrosive contaminants shall be imposed on the test item by the test facility (temperature/humidity chamber).

4.5.6.1 Procedure temperature and humidity. Install the test item in the test facility in accordance with 4.5.2. During the tests specified in 4.5.6.1.1 the relative humidity need not be controlled. Relative humidity of 95 percent (with the applicable tolerance) does not include conditions of precipitation. The rate of temperature change shall be 1 °C to 5 °C per minute. The temperature limits and relative humidity shall be:

Not operating :	-20 °C to +70 °C
Operating:	+10 °C to +40 °C at 5 to 75 percent relative humidity.
	+10 °C to +30 °C at 5 to 95 percent relative humidity.

Precipitation is not authorized during the temperature and humidity test.

4.5.6.1.1 Temperature test procedure. The temperature test procedure consists of a five independent tests (a through e) that can be performed in any sequence, except as indicated for test (a). The profiles provided on Figure 1 demonstrate only one possible sequence of testing. The detailed test procedure at the time of testing shall define the actual test sequence. The humidity during the test is uncontrolled for all tests except test (d), where the humidity shall be controlled within the range of 5 to 20 percent relative humidity (with the applicable tolerance), to simulate an arid environment. The testing may be interrupted after any test, a through e. Performance of the satisfactory operation test shall occur at the end of each temperature test period, adding whatever time is required to perform the satisfactory operation test. (This means that the total time required to perform the temperature testing will be the cumulative total consisting of: the time required for each temperature test, the time required to perform a satisfactory operation test at each temperature test, and any interruption period).

a. Test (a). Place the test item in the test chamber in accordance with 4.5.2. This test is the initial operation verification test. With the temperature at the room ambient the equipment is operating for 2 hours, after which the satisfactory operational test is performed. Test (a) shall always be performed first in the test sequence.

b. Test (b). The temperature is maintained at 10 °C. The equipment is not operating for 4 hours. Operate the test item for the warm-up period recommended by the manufacturer. Perform the satisfactory operation test and compare the results with test (a) in accordance with 4.5.3. No alignment or adjustment of other than the operating controls shall be permitted throughout the test specified.

c. Test (c). The temperature is maintained at -40 °C. The equipment is not operating for 4 hours. Following the 4 hour cold storage soak, the temperature is raised to 23 °C. For an additional 4 hours the equipment is maintained at these conditions. Operate the test item for the warm-up period recommended by the manufacturer. Perform the satisfactory operation test and compare the results with test (a) in accordance with 4.5.3. No alignment or adjustment of other than the operating controls shall be permitted throughout the test specified.

d. Test (d). The humidity during this test is controlled at within the range of 5 to 20 percent (with the applicable tolerance). The temperature is maintained at 40 °C. The

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equipment is operating for 4 hours. Following the 4 hour arid heat operating soak, perform the satisfactory operation test and compare the results with test (a) in accordance with 4.5.3. No alignment or adjustment of other than the operating controls shall be permitted throughout the test specified.

e. Test (e). The temperature is maintained at 71 °C. The equipment is not operating for 4 hours. Following the 4 hour hot storage soak, the temperature is lowered to 23 °C. For an additional 4 hours the equipment is maintained at these conditions. Operate the test item for the warm-up period recommended by the manufacturer. Perform the satisfactory operation test and compare the results with test (a) in accordance with 4.5.3. No alignment or adjustment of other than the operating controls shall be permitted throughout the test specified.

4.5.6.1.2 Procedure, humidity cycle. The humidity cycle testing follows immediately after the testing of 4.5.6.1. This procedure consists of 5 days of temperature humidity cycling, with each day's cycle consisting of the profile displayed on Figure 2. Satisfactory operational tests are performed at the times indicated on the figures with a diamond symbol, noted as (a), (b), and (c) (as applicable). The following Notes 1 through 4 apply:

a. Note 1. A satisfactory operational test (at normal room ambient conditions) shall be conducted prior to and at-the-conclusion of the five-day humidity test.

b. Note 2. During the humidity cycle, the diagnostic equipment is only operating during the warm-up period and the satisfactory operational test.

c. Note 3. The satisfactory operation tests, as annotated by (a), (b), and (c) shall each be performed at least once each during the 5 days of humidity cycling, at the indicated times. Satisfactory operation tests (a) and (b), as appropriate, shall be performed at any of cycles 2, 3, 4, or 5. Satisfactory operation tests (c) shall be performed at least at Cycle 5. Satisfactory operation tests may also be performed at any, or all cycles at the indicated times.

d. Note 4. To accommodate varying times for completing satisfactory operational tests, the cycle timing after a test maybe adjusted to allow a return back to the regular profile timing. However, a minimum 4 hour dwell time prior to period of operation should be observed.

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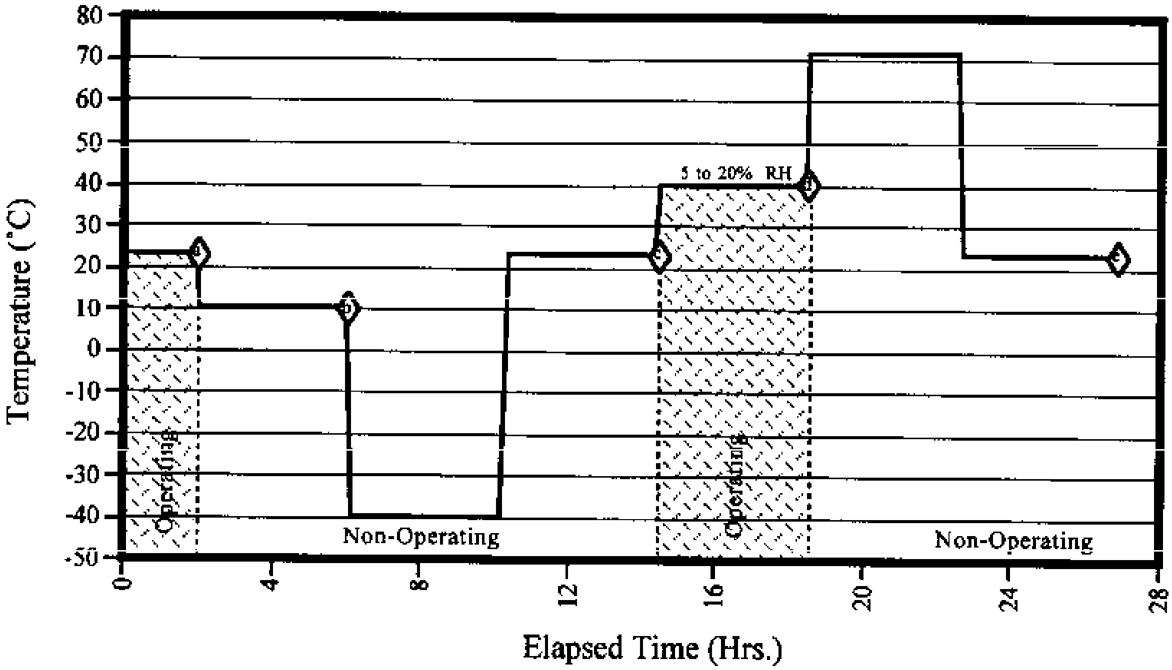

FIGURE 1. Temperature testing profile (including arid climate test).

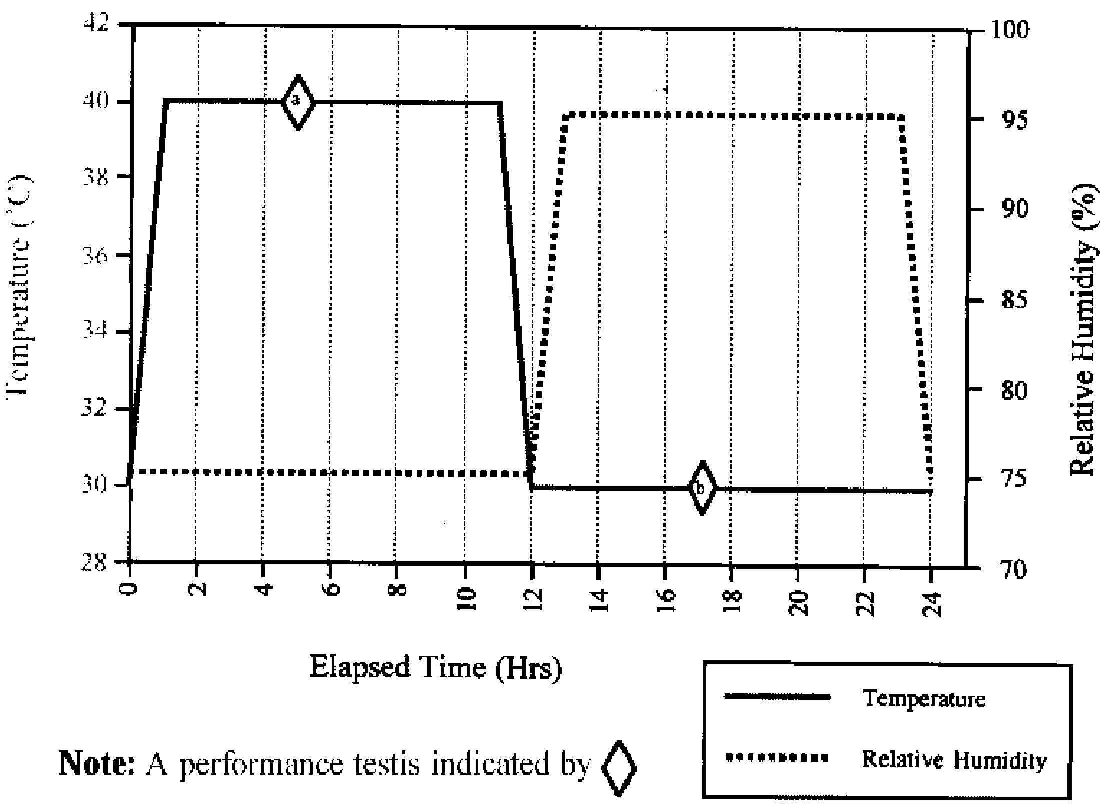

FIGURE 2. Five day humidity cycle profile that follows initial temperature test.

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4.5.7 Altitude test, not operating (see 3.11.2). The altitude test shall be performed as specified in Steps 1 through 4 at the simulated altitude.

a. Step 1. Prepare the test item in accordance with 4.5.2 and maintain the temperature within the specified operating range for the duration of the test. The equipment shall be configured in a mode that can easily be accessed for measurement of conformance to specification. A performance test shall be made at this starting point to determine conformance to specification for the equipment.

b. Step 2. Decrease the chamber pressure to 15,000 feet at a rate not to exceed 2000 feet per minute with the diagnostic equipment not operating for 1 hour.

c. Step 3. With the diagnostic equipment not operating, return the chamber to standard ambient conditions at a rate not to exceed 2,000 feet per minute.

d. Step 4. Perform the satisfactory operation test after return to the test conditions of 4.5.3. Degradation of equipment performance beyond the specified requirements shall constitute a failure.

4.5.8 Fungus resistance (see 3.11.3).

4.5.8.1 Fungus resistance test. The diagnostic equipment shall be tested in accordance with MIL-STD-810, Test Method 508. The diagnostic equipment shall be removed from the test chamber and excess moisture may be removed by turning the diagnostic equipment upside down or by shaking. No washing or wiping of the diagnostic equipment is permitted.

4.5.8.2 Alternative fungus test method. As an alternative, the procuring activity may specify that the manufacturer provide a certified statement stating that no organic material is used in the manufacturing of the diagnostic equipment.

4.5.9 Random vibration tests (see 3.11.4). The vibration tests shall be as specified in 4.5.9.1. If a diagnostic equipment failure occurs, the diagnostic equipment may be repaired at the discretion of the procuring activity. If repair is allowed, testing will continue from the point at which the failure occurred until the remaining test period is completed. The portion of the test period prior to the failure will be repeated to evaluate the integrity of the repair. Failure modes that are not related to the original failure will be disregarded during the retest. At the discretion of the procuring activity, a second unit maybe subjected to the test in lieu of retesting the unit that failed.

4.5.9.1 Background information. Vibration levels on Figure 3 shall be applied to the diagnostic equipment, with durations of 10 minutes per axis. The diagnostic equipment shall be powered off during the vibration test. The diagnostic equipment is to be hard mounted to the table by gripping the equipment's structure. Unless the diagnostic equipment's feet are integral parts of the structure, they should be removed during the test; if they are integral, the diagnostic equipment should be fixed so that the vibration is applied to the structural frame of the diagnostic equipment. At the conclusion of the vibration test, conduct a physical evaluation and a performance test of the diagnostic equipment (see 4.5.2).

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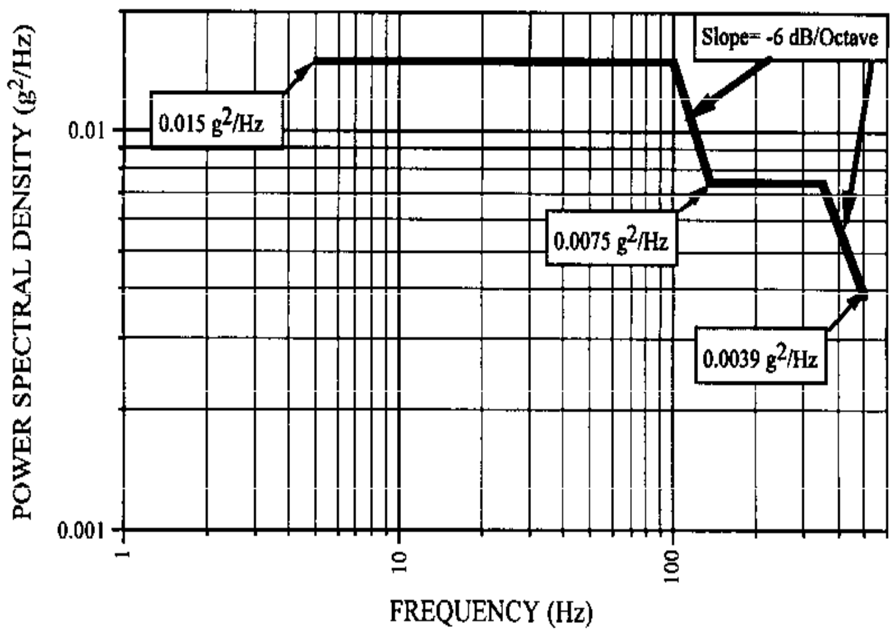

FIGURE 3. Random vibration profile.

4.5.10 Bench handling test (see 3.11.5). With the diagnostic equipment operating as in the satisfactory operating check, place the diagnostic equipment in a suitable position for its servicing on a horizontal, solid wooden bench top at least 4.1 centimeters (cm) thick. The test shall be performed as specified in Steps 1 through 5, in a manner simulating shocks liable to occur during its servicing.

a. Step 1. Using one edge as a pivot, lift the opposite edge of the chassis until one of the conditions specified in a through c occurs (whichever occurs first):

(1) The chassis forms an angle of 45 degrees with the horizontal bench top.

(2) The lifted edge of the chassis has been raised 4 inches above the horizontal bench top.

(3) The lifted edge of the chassis is just below the point of perfect balance.

Let the chassis drop back freely to the horizontal bench top. Repeat, using other practical edges of the same horizontal face as pivot points, for a total of four drops.

b. Step 2. Repeat Step 1, with the diagnostic equipment resting on other faces until the test item has been dropped for a total of four times on each face on which the test item could reasonably be placed during its servicing.

c. Step 3. Repeat Steps 1 and 2 with diagnostic equipment not operating and cabinet or case removed, except for equipment where the case serves as the only chassis or support structure.

d. Step 4. Examine the diagnostic equipment for mechanical damage. Damage to the instrument, other than cosmetic, will constitute a failure.

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e. Step 5. Perform the satisfactory operation test.

4.5.11 Electromagnetic compatibility (EMC) (see 3.11.6). The diagnostic equipment shall be tested in accordance with MIL-STD-461 specific requirements of CE102, CS101, CS114, CS115, CS116, RE102, and RS103.

4.5.12 Government validation. The emulator is capable of generating multiple intermittent faults to simulate 256 LRU/WRA conductive paths. The emulator is capable generating controlled intermittent faults of various durations from 100 nanoseconds to one second at pseudo random time intervals. The diagnostic equipment must successfully detect all the intermittent faults (see 3.17).

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The diagnostic equipment covered by this specification is intended for use in detecting and isolating intermittent faults in LRU/WRA, chassis and backplanes and their wire harnesses. The diagnostic equipment is intended to be used with the LRU/WRA (with SRAs removed) being stimulated by temperature, vibration or vibration/temperature to emulate the environment in which the fault originally occurred. Appendices A through C provide recommended guidelines for defining this external stimulation.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.
b. Title, number, and date of the applicable purchase description.
c. Appropriate category (see 1.2).
d. Number of first article samples (see 4.2).
e. Packaging (see 5.1)
f. If required, the specific issue of documents.
g. First article inspection.
h. Production lot, conformance inspection.
i. The quantity of maintenance and calibration aid sets required will be as specified by the procuring activity, including: circuit board extenders, special adapters, special tools, and patch cables.
j. Waivers are required for equipment that incorporates restricted materials (see 3.10.2). The restricted materials are prohibited except where such materials are

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fabricated into completed approved standard parts, or use of the material is approved by the procuring activity.

k. The equipment manufacturer must have a standard commercial quality assurance program. For example the program could be, but is not required to be certified to ISO 9001 or 9002. Other such recognized commercial quality assurance programs are acceptable.

l. Failure criteria.

m. If required, the location of the identification plate on a transit case must be specified.

n. The requirement for nomenclature assignment and the nomenclature to be assigned.

o. The equipment manufacturer should have a standard Electrostatic Discharge Control Program that complies with the requirements of MIL-STD-1686.

p. The quantity of accessories including, but not limited to: power cords, fuses (if required) , interface cables, etc.

q. The requirement for technical manuals (see technical manuals as defined in MIL-PRF-28800).

r. Microsoft Windows operating system version or Non-Windows operating system.

s. The requirement for Government Validation.

t. Marking (see 3.12).

u. Number of test points per modular unit and maximum amount of test point expansion.

6.3 First article inspection. When first article inspection is required, the equipment should be first production units. The contracting officer should include specific instructions in procurement documents regarding arrangements for examinations, approval of first article test results, and disposition of first articles.

6.4 Definitions.

6.4.1 Expandability. The ability of the base equipment to be interfaced with expansion equipment in logical increments to handle a growing amount of test points in a capable manner or its ability to be enlarged to accommodate that growth (e.g., increments of 64, 128, 256, test points, etc.).

6.4.2 Intermittent faults. Intermittent faults are short duration discontinuities (opens/shorts) that occur in conductive paths in LRU/WRA chassis/ backplanes. Intermittent faults occur as a result of various operational environmental stimuli, including, but not limited to, thermal stress, vibrational stress, gravitational G-force loading, moisture and/or contaminant exposure, as well as changes in the material due to age and use, such as the growth of tin whiskers, metal migration and delamination of materials. These faults can occur individually and /or in rapid succession on any chassis or backplane circuit. Fault durations range in time from nanoseconds to milliseconds and have variable impedances. These circuit path disruptions are frequently caused by: cracked solder joints; intermittent coax lines (e.g., shield corrosion, damaged center conductor, etc.); broken, cracked or frayed wires; loose clamps; and unsoldered pins. These circuit path disruptions often cause functional failures/faults in LRU/WRA chassis and backplanes whose root cause(s) cannot be detected and isolated using traditional automatic test equipment (ATE) and troubleshooting processes. Lacking the ability to detect and isolate intermittent failures and provide environmental stimuli during test and repair process, such assets

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are commonly reported as no-fault-found (NFF) or as one of the quasi-NFF repair codes (e.g., cannot duplicate (CND), retest OK (RETOK), beyond capability of maintenance (BCM), disassemble-clean-reassemble (DCR), etc.).

6.4.3 Fault isolation. The ability to locate the fault to a single/multiple conductive path(s).

6.4.4 Conductive path. Includes but is not limited to: wiring, circuit board traces, shields, bonding straps, connectors, jumpers, solder joints, connectors, etc.

6.4.5 Short duration fault. A short duration fault is a fault with duration under 100 nanoseconds and/or low resistance under 10 ohms. The random occurrence of these short duration faults can cause problems in high frequency (10 MHz or higher) or sensitive or critically balanced circuits.

6.4.6 Intermediate duration fault. An intermediate duration fault is a fault which has duration between 101 nanoseconds and 501 microseconds and/or low resistance between 50 to 500 ohms.

6.4.7 Long duration fault. A long duration fault is a fault which has duration between 500 microseconds and 5 milliseconds and/or high resistance (500 ohm to open).

6.4.8 Failure. Equipment failure as used herein is any departure from the required performance or operation outside of the required accuracies (not correctable by normal use of the operating controls), or deviation from the criteria of 4.5 after the test is initiated.

6.4.9 Bench-top equipment. Bench-top equipment is designed to be used on a fixed bench or table or on a mobile cart. Equipment that exceeds 5 kg in weight and has no handles, or exceeds 20 kg with or without a handle, is considered to be bench-top equipment.

6.4.10 Depot maintenance. Maintenance performed on material requiring major overhaul or a complete rebuild of parts, subassemblies and end items, including the manufacture of parts, modifications, testing, and reclamation. Depot maintenance serves to support lower echelons of maintenance by providing technical assistance and performing maintenance beyond their capability. Depot maintenance provides stocks of serviceable equipment by using more extensive facilities for repair than are available in lower level maintenance activities.

6.4.11 Open. An open, commonly referred to as an open circuit, is an abnormal or unintended loss of continuity that can occur in one or more conductive paths in the LRU/WRA chassis/backplane. This results in an interruption or loss electric current in the case of a power circuit or an abnormal or interruption or loss of signal in one or more conductive paths. The impedance of this conductive path is equal to the total impedance of the abnormal/unintended conductive path. The open impedance of the abnormal/unintended conductive path is defined as greater than 10 kilohms.

6.4.12 Short. A short, commonly referred to as a short circuit, is an abnormal or unintended connection between two conductive paths in the LRU/WRA chassis/backplane. This results in an increased electric current/over current in the case of a power circuit or an abnormal or unintended signal on two or more conductive paths. The impedance of this conductive path is equal to total impedance of the abnormal/unintended conductive path. The short impedance of the abnormal/unintended conductive path is defined as less than 10 ohms.

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6.5 Government validation. The diagnostic equipment may be tested in a laboratory environment by the government using an Intermittent Fault Emulator. The emulator is capable of generating multiple intermittent faults to simulate 256 LRU/WRA conductive paths. The emulator is capable generating controlled intermittent faults of various durations from 100 nanoseconds to one second at pseudo random time intervals.

6.6 Physical characteristics. Diagnostic equipment design should consider the human factors engineering design principles of MIL-STD-1472, to ensure the equipment can be operated effectively and safely in its intended environment by appropriately trained personnel. All components should be selected and located for maximum ease of operation, inspection, and maintenance.

6.7 Subject term (key word) listing.

Connectors
Intermittent
Long Duration
Shorts
Terminal Boards
Wire Harness

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VIBRATION STIMULATION

A.1 SCOPE

A.1.1 Scope. This appendix details ways to isolate failures related to vibration. This appendix is not a mandatory part of the specification. The information contained herein is for guidance only.

A.2 DETERMINING CAUSES OF INTERMITTENT FAILURES

A.2.1 Introduction. Each LRU/WRA is different in its function and operational environment. As a result, no single test method or procedure can adequately replicate an intermittent fault occurrence for all LRUs/WRAs. A careful review of the nature of the failure and the operational conditions under which the failure occurred is required. The following steps are recommended when by careful analysis it is determined that the failures occur during ground or flight operating conditions, and the operating temperature does not appear to be contributing to the occurrence of the failures.

A.2.2 Typical resulting effects. The following is a list of typical resulting effects of vibration-induced problems (this list is not intended to be all-inclusive):

a. Chafed wiring.
b. Loose fasteners/components
c. Intermittent electrical contacts
d. Electrical shorts.
e. Deformed seals.
f. Failed components.
g. Optical or mechanical misalignment.
h. Cracked and/or broken structures.
i. Migration of particles and failed components.
j. Particles and failed components lodged in circuitry or mechanisms.
k. Excessive electrical noise.
l. Fretting corrosion in bearings.

A.2.3 Operational vibration environment. A review should be conducted of technical manuals, operating manuals and any available information which provides insight into the operational vibration environment of the LRU/WRA. As much as practical this information should be used to tailor a vibration envelope for vibrating the LRU/WRA while troubleshooting the LRU/WRA for intermittent faults. It is not necessary to vibrate the LRU/WRA at full qualification levels which may induce additional failure modes. It is recommended that where the operational are not known, the qualification vibration test levels may be reduced by a factor of eight and used during troubleshooting of the LRU/WRA. The intent is to subject the LRU/WRA to a vibration level high enough to stimulate the intermittent fault, but not reduce the operational life of the LRU/WRA.

A.2.3.1 Unknown operational limits. Where the vibration operational limits are unknown, MIL-STD-810, Test Method 514 should be used to tailor the LRU/WRA vibration stimulation test sequence as a function of the life cycle environments of the LRU/WRA:

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A.2.3.1.a. General. The accumulated effects of vibration-induced stress may affect LRU/WRA performance under other environmental conditions such as temperature, altitude, humidity, leakage, or electromagnetic interference (EMI/EMC). When evaluating the cumulative environmental effects of vibration and other environments, expose the LRU/WRA to all environmental conditions, with vibration testing generally performed first. If another environment (e.g., temperature cycling) is projected to produce damage that would make the LRU/WRA more susceptible to vibration, perform tests for that environment before vibration tests. For example, thermal cycles might initiate a fatigue crack that would grow under vibration or vice versa.

A.2.3.1.b. Unique to this method. Generally, expose the LRU/WRA to the sequence of individual vibration tests that follow the sequence of the life cycle. For most tests, this can be varied if necessary to accommodate test facility schedules, or for other practical reasons. Complete any maintenance associated preconditioning prior to tests representing mission environments. Perform tests representing critical end-of-mission environments last.

A.2.4 Worst case operational vibration. Functional testing is conducted to verify that the LRU/WRA functions as required while exposed to worst case operational vibration. Functional level vibration testing in accordance with MIL-STD-810, Test Method 514 is recommended. Fully verify the function at the beginning, middle and end of each test segment. Monitor basic separate functional and endurance tests are required, split the functional test duration, with one half accomplished before the endurance test, and one half after the endurance test (in each axis). The duration of each half should be sufficient to fully verify materiel function. This arrangement has proven to be a good way of adequately verifying that materiel survives endurance testing in all respects. In some cases, materiel that must survive severe worst case environments may not be required to function or function at specification levels during worst case conditions. Typically "operating" and "non-operating" envelopes are established. Tailor functional tests to accommodate non-operating portions by modifying required functional monitoring requirements as appropriate.

A.2.4.1 Category 7 (see MIL-STD-810, Test Method 514), jet aircraft. Vibration environments on jet aircraft are broadband random in nature. The maximum vibrations are usually engine exhaust noise generated and occur during takeoff. Levels drop off rapidly after takeoff to lower level cruise levels that are boundary layer noise generated.

A.2.4.2 Category 8 (see MIL-STD-810, Test Method 514), propeller aircraft. Vibration environments on propeller aircraft are dominated by relatively high amplitude, approximately sinusoidal spikes at propeller passage frequency and harmonics. Because of engine speed variations, the frequencies of the spikes vary over a bandwidth. There is wide band vibration at lower levels across the spectra. This wide band vibration is primarily due to boundary layer flow over the aircraft.

A.2.4.3 Category 9 (see MIL-STD-810, Test Method 514), helicopter. Vibration environments on helicopters are characterized by a continuous wideband, low-level background with strong narrowband peaks superimposed. This environment is a combination of many sinusoidal or near sinusoidal components due to main and tail rotors, rotating machinery and low-level random components due to aerodynamic flow.

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TEMPERATURE STIMULATION

B.1 SCOPE

B.1.1 Scope. This appendix deals with ways to isolate faults related to operating temperature. This appendix is not a mandatory part of the specification. The information contained herein is for guidance only.

B.2 DETERMINING CAUSES OF INTERMITTENT FAILURES

B.2.1 Introduction. Each LRU/WRA is different in its function and operational environment. As a result, no single test method or procedure can adequately replicate an intermittent fault occurrence for all LRUs/WRAs. A careful review of the nature of the failure and the operational conditions under which the failure occurred is required. The following steps are recommended when by careful analysis it is determined that the failures occur during ground or flight operating conditions, and the operating temperature appears to be contributing to the occurrence of the failures.

B.2.2 Typical resulting effects. The following is a list of typical resulting effects of temperature-induced problems (this list is not intended to be all-inclusive):

a. Binding or slackening of moving parts.
b. Deformation or fracture of components.
c. Cracking of surface coatings.
d. Leaking of sealed compartments.
e. Failure of insulation protection.
f. Differential contraction or expansion rates or induced strain rates of dissimilar materials.
g. Intermittent electrical contacts.
h. Electrical shorts/opens.
i. Failed components.
j. Changes in electrical and electronic components.
k. Electronic or mechanical failures due to rapid water or frost formation.
l. Excessive static electricity.

B.2.3 Operational temperature environment. A review should be conducted of technical manuals, operating manuals and any available information that provides insight into the operational temperature environment of the LRU/WRA. As much as practical, this information should be used to tailor a temperature cycling profile for temperature stressing the LRU/WRA while troubleshooting the LRU/WRA for intermittent faults. It is not necessary to temperature cycle the LRU/WRA at full qualification levels which may induce additional failure modes. It is recommended that where the operational temperature test levels are not known that the qualification temperature levels during troubleshooting of the LRU/WRA be reduced in order to not over stress the LRU/WRA. The intent is to subject the LRU/WRA to a temperature level low/high enough to stimulate the intermittent fault, but not reduce the operational life of the LRU/WRA.

B.2.3.1 Unknown temperature operational limits. Where the temperature operational limits are unknown, MIL-STD-810, Test Method 503 should be used to tailor the LRU/WRA temperature stimulation test sequence as a function of the life cycle environments of the

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LRU/WRA. It should be noted that Test Method 503 is a temperature shock test method and should be tailored to represent the operational temperature changes that the LRU/WRA is exposed to in its operating environment. Procedure I-C, Multi-cycle shocks from constant extreme temperature or Procedure I-D, Shocks to or from controlled ambient temperature is recommended depending on the operational environment of the LRU/WRA.

B.2.3.1.1 Information collection. During the temperature cycling testing, the following information should be collected:

a. Record of chamber temperature versus time conditions.
b. Test item temperatures (measured locations).
c. Transfer times (e.g., "door open" to "door closed").
d. Duration of each exposure.
e. Conductive path intermittent fault location.

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TEMPERATURE/VIBRATION STIMULATION

C.1 SCOPE

C.1.1 Scope. This appendix deals with ways to isolate faults related to a combination of operating temperature and vibration. This appendix is not a mandatory part of the specification. The information contained herein is for guidance only.

C.2 DETERMINING CAUSES OF INTERMITTENT FAILURES

C.2.1 Introduction. LRU/WRAs are different in their function and operational environments. As a result, no single test method or procedure can adequately replicate an intermittent fault occurrence for all LRUs/WRAs. A careful review of the nature of the failure and the operational conditions under which the failure occurred is required. The following steps are recommended when by careful analysis it is determined that the failures occur during ground or flight operating conditions.

C.2.2 Typical failures. Temperature, humidity, vibration, and altitude can combine synergistically to produce the following failures. Although altitude is included in the following discussion typically in regards to LRU/WRA operating environment it mainly impacts cooling and is a function of temperature. Typically Combined Environmental Test facilities do not include altitude test capability. The following examples are not intended to be comprehensive:

a. Shattering of optical material. (Temperature/Vibration/Altitude)
b. Binding or loosening of moving parts. (Temperature/Vibration)
c. Separation of constituents. (Temperature/Humidity/Vibration/Altitude)
d. Performance degradation in electronic components due to parameter shifts (Temperature/Humidity)
e. Electronic optical (fogging) or mechanical failures due to rapid water or frost formation. (Temperature/Humidity).
f. Differential contraction or expansion of dissimilar materials. (Temperature/Altitude)
g. Deformation or fracture of components. (Temperature/Vibration/Altitude)
h. Cracking of surface coatings. (Temperature/Humidity/ Vibration/Altitude)
i. Leakage of sealed compartments. (Temperature/Vibration//Altitude)
j Failure due to inadequate heat dissipation. (Temperature/Vibration /Altitude)

C.2.3 Combined forcing functions. A review should be conducted of technical manuals, operating manuals and any available information, apply the tailoring process in MIL-STD-810 to determine where these combined forcing functions of temperature, humidity, vibration, and altitude are foreseen in the LRU/WRA operational environment Use this method only if the proper engineering has been performed such that the environmental stresses associated with the individual methods are encompassed by the combined test. If appropriate, tailor storage thermal environments into the combined environmental cycle; or, perform them as separate tests, using the individual test methods. Use the following to aid in selecting this method and placing it in sequence with other methods.

C.2.3.1 Unknown operational limits. Where the temperature/vibration/humidity/altitude operational limits are unknown, MIL-STD-810, Test Method 520 should be used to tailor the

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LRU/WRA temperature/vibration stimulation test sequence as a function of the life cycle environments of the LRU/WRA:

C.2.3.1.1 Vibration. Four vibration profiles may be used:

a. A random test profile with the following parameters is an example of temperature/vibration:
b. A 20-800 Hz random profile where $G^2/Hz = 0.0051282$ and G RMS = 2
c. A 20-300 Hz sine sweep that runs for 3:54 where G = 2
d . A 20-300 Hz sine sweep that runs for 0:15 where G = 2

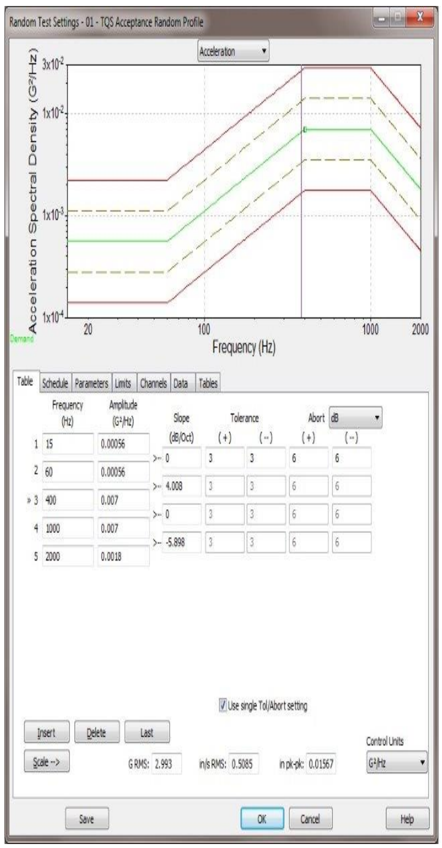

FIGURE C-1. Example random vibration test profile.

C.2.3.1.2 Temperature:

a. Initially the vibration profiles are run at room temperature, approximately 24 ^{o}C
b. The temperature is then dropped to -0 ^{o}C at 5 ^{o}C/minute and vibration profiles are run as the temperature drops.
c. The temperature is then held at -0 ^{o}C for a 15-minute soak time, during which time the vibration profiles are run.

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d. The temperature is then dropped to -40 ^{o}C at 5 ^{o}C/minute and vibration profiles are run as the temperature drops.
e. The temperature is then held at -40 ^{o}C for a 15-minute soak time, during which time the vibration profiles are run.
f. The temperature is then raised to 70 ^{o}C at 5^{o}C/minute and vibration profiles are run as the temperature rises.
g. The temperature is then held at 70 ^{o}C for a 15-minute soak time, during which time the vibration profiles are run.
h. Finally, the temperature is returned to room temperature at 5 ^{o}C/minute and vibration profiles are run as the temperature falls.

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CONCLUDING MATERIAL

Custodians:
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Navy - AS
Air Force - 85

Review activity:
Air Force - 99

Preparing activity:
Navy - AS
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